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# MULTIMEDIA UNIVERSITY

## FINAL EXAMINATION

TRIMESTER 1, 2019/2020

### EMF3046 – RF MEASUREMENT TECHNIQUES (TE)

16 OCTOBER 2019  
2.30 P.M - 4.30 P.M.  
(2 Hours)

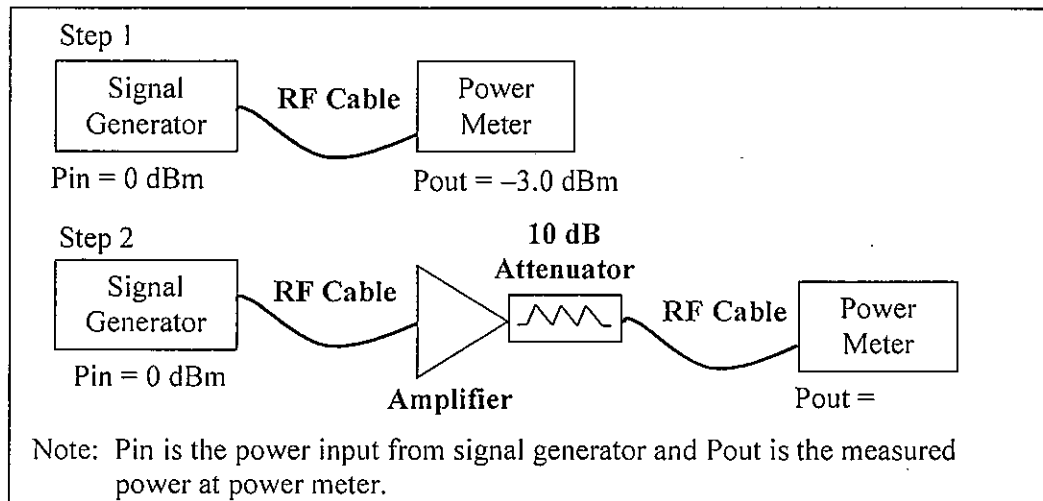
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#### INSTRUCTION TO STUDENT

1. This Question paper consists of 6 pages with 4 Questions only.
2. Answer all **FOUR (4)** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Constants and formulae are given in Appendix A(page 5).
4. A Smith Chart is given.
5. Please **WRITE** all your answers in the Answer Booklet provided and submit any graph used.

**Question 1**

- a) Explain why voltage and current are not measured at high frequency in the determination of signal power. (4 Marks)
- b) With an aid of a diagram, show the relationship between the current density with respect to distance from the outer conductor due to Skin effect. Explain its impact at RF. (9 Marks)
- c) A power RF amplifier is to be deployed in one of the RF circuit application. The minimum required power gain is 30.0 dB. There are 2 power amplifiers available for selection. Both of them are tested under the following configuration as shown in Figure Q1. The amplifier is measured via 2 steps.

**Figure Q1**

The measured  $P_{out}$  for Amplifier 'A' and 'B' are 45.0 dBm and 50.0 dBm respectively.

All the RF cables used have identical losses. The total loss for all the connectors used in the setup is 2.0 dB.

- (i) Explain why it is necessary to have attenuator in the set up. (3Marks)
- (ii) Determine the gain of the two amplifier under test. (6Marks)
- (iii) Are both amplifiers meet the requirement? Give reason for your answer. (3 Marks)

**Question 2**

- (a) How many types of power measurements in RF measurement? Describe each of them. (7 Marks)

**Continued...**

- (b) With an aid of a diagram, state what are the parameters that can be obtained from Transmission and Reflection measurement. (6 Marks)
- (c) An unknown device load is connected to a transmission line of characteristic impedance of  $60 \Omega$ . The source power used was 1mw. The device was tested under frequency of 900 MHz and source power of 1mw. The following experimental results were observed:  
 $V_{\max} = 24.2 \mu\text{v}$  at a distance 2.00 cm from the load.  
 $V_{\min} = 10.0 \mu\text{v}$  at distance 10.33 cm from the load.  
 Assuming the dielectric constant of the line is approximately equal to 1, by using smith chart or calculation, obtain the unknown load impedance. (9 Marks)
- (d) Would you expect to observe another  $V_{\max}$ ? If yes, what would be the distance from the load. If no, why? (3 Marks)

### Question 3

- (a) With an aid of a schematic diagram, show the THREE systematic errors relationship with respect to  $S_{11}$  under ideal and non-ideal ONE port calibration model. (7 Marks)
- (b) Describe how to obtain those systematic errors through measurement? (4 Marks)
- (c) A newly designed device has been tested under 2 different types of calibration. The following S-parameters were recorded at 1.2 GHz as shown in Table Q3. The impedance used in calibration techniques is  $75 \Omega$ .

Table Q3

Before Calibration (Uncorrected)	After 1-Port SOL Calibration	After 2-Port SOLT Calibration
$S_{11} = 0.40 \angle 30^\circ$ $S_{21} = 0.3 \angle 30^\circ$	$S_{11} = 0.02 \angle 0^\circ$ $S_{21} = 0.40 \angle 15^\circ$	$S_{11} = 0.01 \angle 0^\circ$ $S_{21} = 0.50 \angle 20^\circ$

Calculate the following parameters for before and after for both calibrations:

- (i) The input impedance. (7 Marks)
- (ii) The return loss in dB. (3 Marks)
- (iii) Is this device produces amplification or attenuation? What is the power gain or power loss in dB after 2-Port calibration? (2 Marks)
- (d) Comment on the results before and after calibration. (2 Marks)

Continued...

**Question 4**

(a) Define Noise Figure and Noise Temperature

(7 Marks)

(b) Show that the expression for noise figure of a cascaded system as shown in Figure Q4A is given by

(8 Marks)

$$F = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2}$$

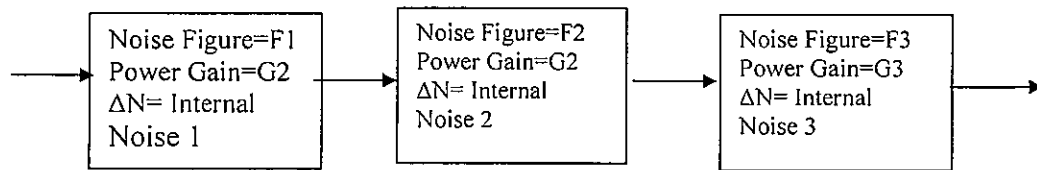


Figure Q4A

(c) Obtain the overall noise temperature of the cascaded system.

(3 Marks)

(d) The block diagram of a RF test system is configured as shown in Figure Q4.

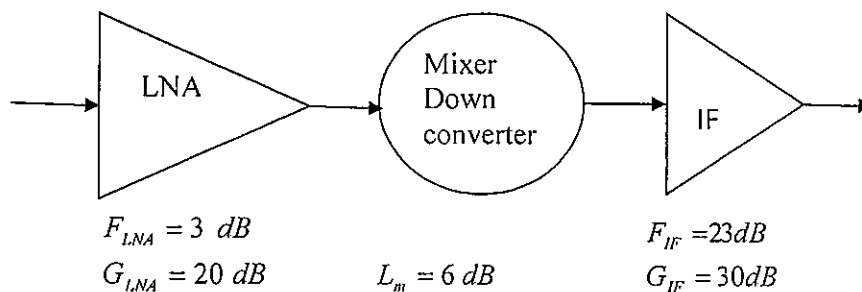


Figure Q4B

Calculate the overall noise figure in dB of the set up.

(5 Marks)

(d) Could the overall noise figure be improved? If yes, how much can it be improved? If no, explain why.

(2 Marks)

Continued...

**APPENDIX A**

Constants and Formulae (All symbols have their usual meanings)

Boltzmann's constant  $k = 1.38 \times 10^{-23} \text{ J/K}$

Light velocity in free space  $c = 3 \times 10^8 \text{ m/s} = f\lambda$

$$Z_0 = \sqrt{\frac{R + j\omega L}{G + j\omega C}}$$

$$\Gamma = \frac{Z_L - Z_0}{Z_L + Z_0}$$

$$Z_{in} = Z_0 \frac{1 + S_{11}}{1 - S_{11}}$$

$$Z_L = Z_0 \frac{1 + \Gamma}{1 - \Gamma}$$

$$SWR = \frac{|E_{\max}|}{|E_{\min}|} = \frac{1 + \rho}{1 - \rho}$$

$$RL = -20 \log |S_{11}|$$

One port Error model:

$$S_{11M} = E_D + E_{RT} \left[ \frac{S_{11A}}{1 - E_S S_{11A}} \right]$$

**End of Questions.**

# The Complete Smith Chart

## Black Magic Design

